Sleep Team

Astronauts report an average sleep period of five to six hours compared with a typical period of seven to eight hours on Earth. Some of this may be due to shifting schedules, lack of privacy, confined quarters, and noises and other interruptions.

A clear understanding of the problem is a missing piece in the puzzle of how the body works in space. With the trend toward extended missions and the International Space Station, the issues become compelling.

On Neurolab, investigators will seek both answers and an effective countermeasure through two individual but complementary studies, the overall goal being to improve the quality of sleep for future astronauts.

The team will study the naturally occurring hormone melatonin to determine its value as a sleep aid and its effects on daytime performance, how changes in respiration alter sleep and how sleep disturbances alter breathing. Astronauts will be given either melatonin or a placebo before sleep. Neither astronauts nor investigators will know who receives the melatonin. Subjects will wear a sleep cap that monitors the electrical impulses from the brain, muscles, eyes and heart.

Changes in respiration may be one of the reasons sleep is disturbed. Crew members will breathe varying gas mixtures while compositions and flow rates are recorded using a gas analyzer. Motions of the rib cage and abdomen, oxygen levels in the blood, arterial blood pressure and heart rate will be recorded.

Vestibular Team

After a shuttle commander brings the spacecraft to a smooth landing, other challenges must be met.

The crew now is feeling gravity for the first time in days and perhaps weeks. They may feel unsteady on their feet and have difficulties with balance. Simple tasks like walking down stairs or turning corners now may be difficult. The crew is experiencing the consequences of a successful adaptation to space. Their symptoms will persist until their vestibular system—the balance organs in the ear and all the connections they make to the eyes, brain and muscles—readapt to Earth.

What changes have taken place in the inner ear? How has the brain learned to ignore some information and reinterpret other signals to allow the astronaut to be productive in space?

These are the questions being asked by the Vestibular Team. To answer these questions, special techniques are necessary. The inner ear resides in the densest bone in the body and does not give up its secrets easily. The investigators will use two noninvasive, but powerful techniques to study the inner ear—centrifugation and eye movement measurement.

Studies on the ground have shown that movements of the eyes accurately reflect what happens in the inner ear. For example, while the body is spinning, the eyes naturally move in a direction opposite to the motion of the head or body. When the eye reaches the extreme of its travel, quick corrective movements bring the eye back; then the eye moves again opposite to the direction of rotation. A similar reaction occurs when the body is tilted.

On Neurolab, crew members acting both as operators and subjects will use an off-axis rotator developed by the European Space Agency to stimulate the vestibular system with both spinning and tilting sensations. Infrared video cameras will capture the eye movements that accompany the spinning. Eye movements will reflect changes in how the vestibular system responds.

Looking at a pattern of stripes moving across the visual field will produce the same type of eye movements that beginning or ending rotation does. In space, the astronauts will look at striped patterns while rotating in the chair. By measuring eye movements, investigators can obtain a measure of how the spatial orientation changes.

"The finding that spatial orientation is reflected in eye movements offers us a powerful tool for testing how spatial orientation changes in space," said Dr. Bernard Cohen of the Mount Sinai School of Medicine. "These studies should help us understand normal balance better and suggest causes for imbalance and falling on Earth."

Neuronal Plasticity Team

Life evolved in Earth 's gravitational field, and animals learned tasks such as walking under the force of gravity. When the gravity load is reduced, as it is in space, the nervous system is challenged. The brain must relearn many tasks to compensate for the new environment. The fact that people can function well in space shows that the nervous system can compensate effectively through what is called neuronal plasticity, a phenomenon in which neurons react to changed conditions or using existing connections in different ways. At the cellular level, neuronal plasticity *is* learning.

On Neurolab, investigators will study neuronal plasticity to understand how balance, daily rhythms and the control of movement change in microgravity. Using rats, investigators will explore how learning occurs in space by measuring changes that take place in the central nervous system. Specifically, they will look at changes in tiny calcium crystals that rest on specialized nerve cells, in the firing patterns of nerve cells in the hippocampus area of rats' brains, and the rats' internal clocks.

Experiments on vestibular adaptation will yield a better understanding of balance disorders that affect more than 90 million Americans.

Neurobiology Team

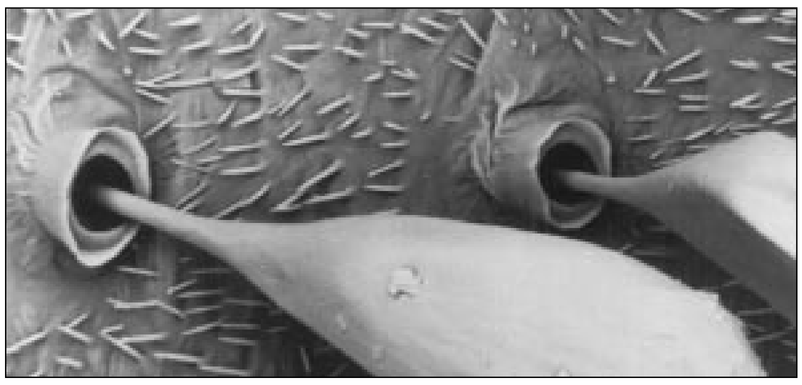
In many Neurolab experiments, investigators are searching for pieces to one particular space life sciences puzzle-the puzzle of how much of normal development is preprogrammed in genes and how much depends on cues from the environment, such as gravity.

As it turns out, the domestic cricket may be able to help. Crickets have gravity sensors connected to a simple and well-studied nervous system. This means that the development of the gravity sensors and the connections they make to the nervous system can be studied comprehensively both with and without gravity. The crickets develop rapidly during the long flight.

The cricket has another sensory system located next to the gravity receptors. This system is comprised of wind or air current receptors, and there is no reason to expect that these should change without gravity. By comparing the development of the gravity receptors and their connections to the nervous system with the development of the wind receptors and their connections, the effect of microgravity should be revealed.

After the flight, the consequences of developing in space will be measured. Crickets roll their heads when tilted, and this reflex is activated by the gravity sensing system. By studying head rolling after the flight, investigators can measure the behavioral consequences of having a nervous system that was built in space.

On orbit, the crickets will be kept in the Botany Experiment Incubator developed by the German Space Agency. The incubator contains a rotating compartment that simulates various levels of gravitational force. Investigators will use BOTEX to compare development of two groups of crickets in early growth stages. One group will develop in microgravity, the other in simulated gravity in an effort to determine how much of normal development is preprogrammed in genetic code and how much can be modified by the environment and experiences.



Mammalian Development Team

A surgeon successfully removes a cataract from one eye of a 50-year-old man who has been blind since birth because of cataracts. When the bandages are removed, an examination reveals that the eye functions acceptably. The patient can see, but he cannot perceive size or distance, recognize faces or understand the colors and shapes he sees.

Neuroscientists are finding increasing evidence that if the nervous system is not exposed to normal forms of stimuli, such as vision, at specific periods during development, the nervous system will not develop properly. Since the patient didn't receive normal stimulation in early childhood, the visual cortex remained underdeveloped and while the eyes could see, the brain did not get the message.

Experiments on previous shuttle missions indicate that gravity, an ever present stimulus in our Earth environment, also may be essential to normal development. The identification of "sensitive" and "critical" periods of development will add a vital piece to the life sciences puzzle.

On Neurolab, investigators will study the development of muscles, the vestibular system, the cardiovascular system and many parts of the brain using rats and mice at various stages of development.

These studies will look at critical periods in the development of the balance system and hippocampus, whether basic motor skills such walking or swimming can be learned without gravity, whether the cardiovascular control system develops normally in space and whether the proliferation of nerve cells—a necessary condition for normal development—is affected by gravity.

Just as we have the ability at birth to learn whatever language we are exposed to, we may also have the ability to adapt to whatever gravitational field we experience early in life. These abilities often exist only during a "critical period." Afterward, our potential is limited. Understanding the nature of these critical periods is important in pediatrics. Knowledge of the critical period for developing normal vision already has changed how "lazy eye" is treated in children.

Aquatic Team

Gravity sensing systems in snails and fish will be used to study questions of how the vestibular system adjusts in microgravity. Investigators will look at physiological changes in the components of gravity sensors, whether signals sent from the inner ear to the brain are altered, and if they are, if behavior changes.

The gravity sensing system is basically the same in fish and humans. In humans, this system is a component of the inner ear. Snails have an even simpler system, which is easier to analyze and develops faster. The gravity sensing component is lined with hair cells that send signals to the brain when they are triggered. The "triggers" are small rock-like particles of calcium carbonate, referred to as statoliths in snails and otoliths in fish and humans. With the tug of gravity, these triggers bend different groups of hair cells, which send orientation signals to the brain.

Investigators will use fresh-water snails and swordtail fish in the early stages of development to study the effects of microgravity on the formation of statoliths and otoliths. The fish and snails will be housed in the Closed Equilibrated Biological Aquatic system developed by the German Space Agency.

Investigators also will look at the Oyster Toadfish to understand changes in the signals sent by the astronauts' inner ears as they adapt to microgravity. Nerve impulse data will be collected and measured in an experiment using a wireless telemetry system devised by the National Space Development Agency of Japan in the Vestibular Function Experiment Unit, an aquatic habitat for saltwater fish.